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(54) **ENHANCED DATA LINK COMMUNICATION OVER IRIDIUM**

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See application file for complete search history.

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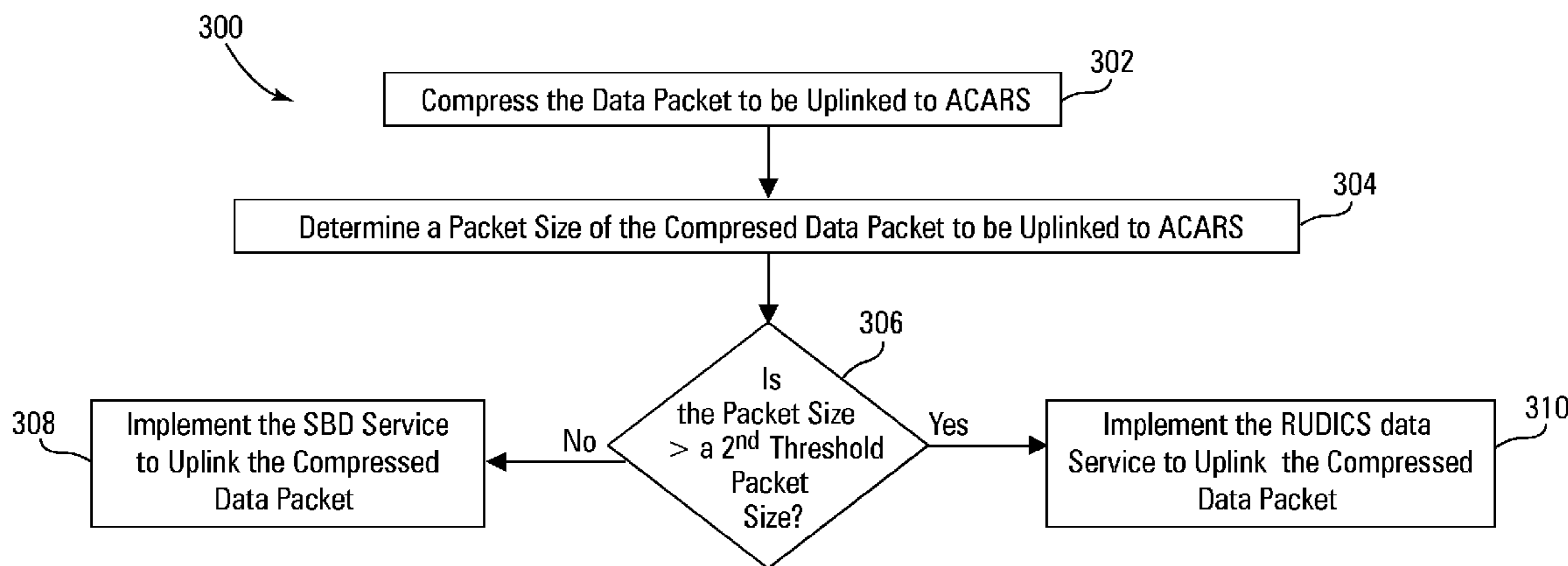
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(57) **ABSTRACT**

A method to reduce latency in a data link communication is provided. The method includes compressing a data packet to be uplinked from a ground station to an aircraft communications addressing and reporting system (ACARS) in an aircraft and determining a packet size of the data packet. The aircraft communications addressing and reporting system is configured to receive packets having a packet size less than or equal to a first threshold packet size. An Iridium router based unrestricted digital inter-working connectivity solution data service is implemented to uplink the compressed data packet if the packet size exceeds a second threshold packet size. A short burst data service is implemented to uplink the compressed data packet if the packet size is less than or equal to the second threshold packet size.

**20 Claims, 8 Drawing Sheets**



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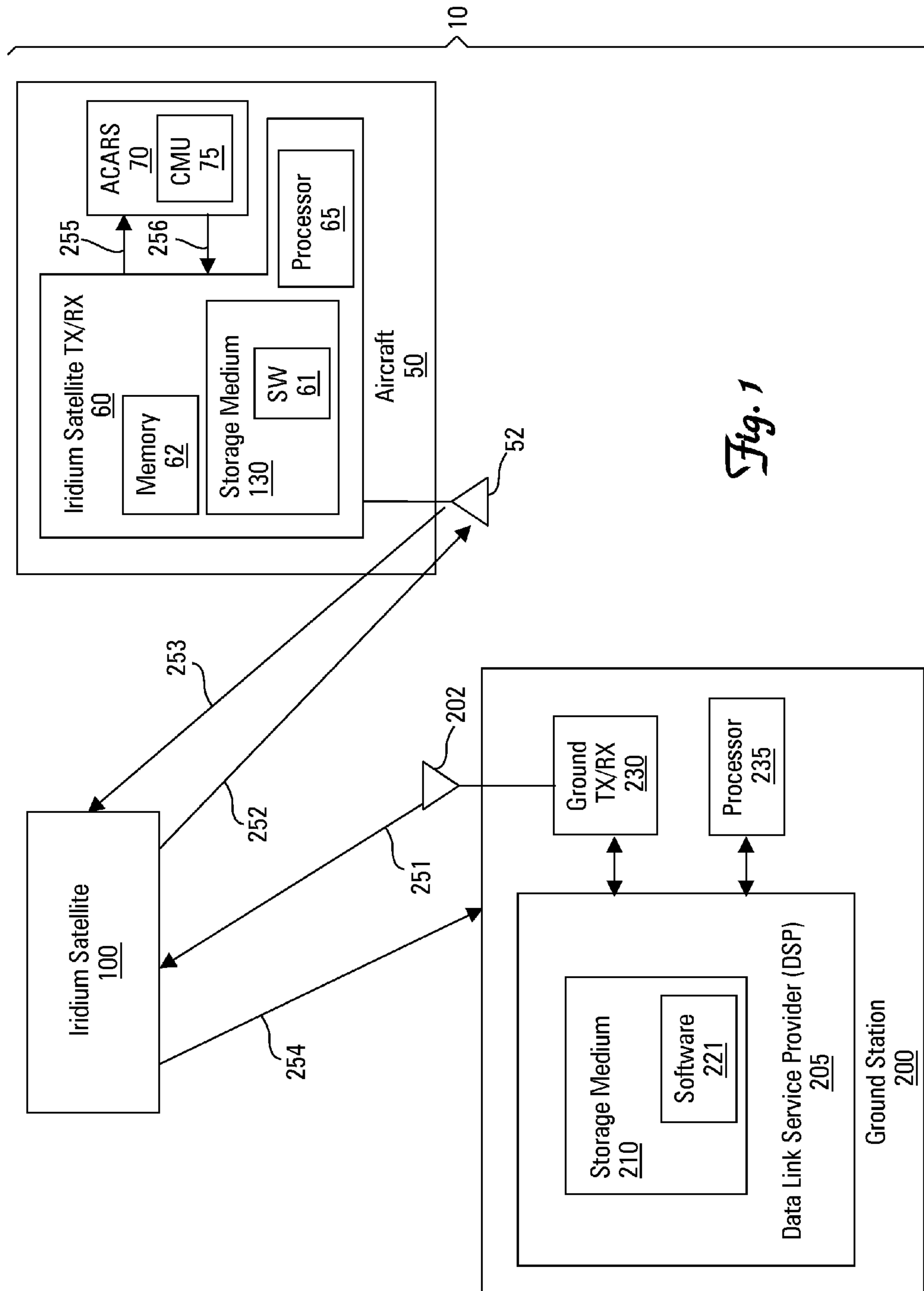


Fig. 1

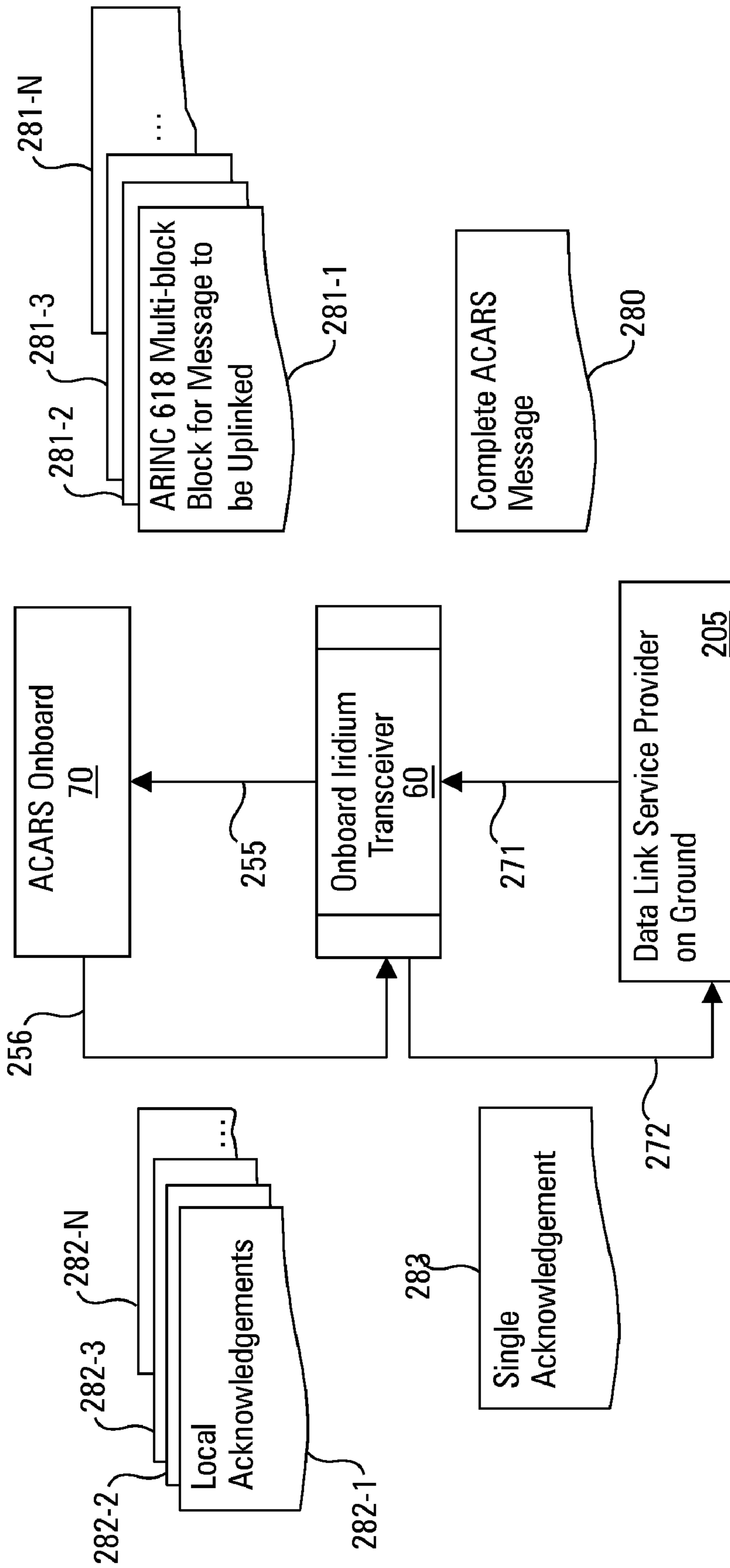
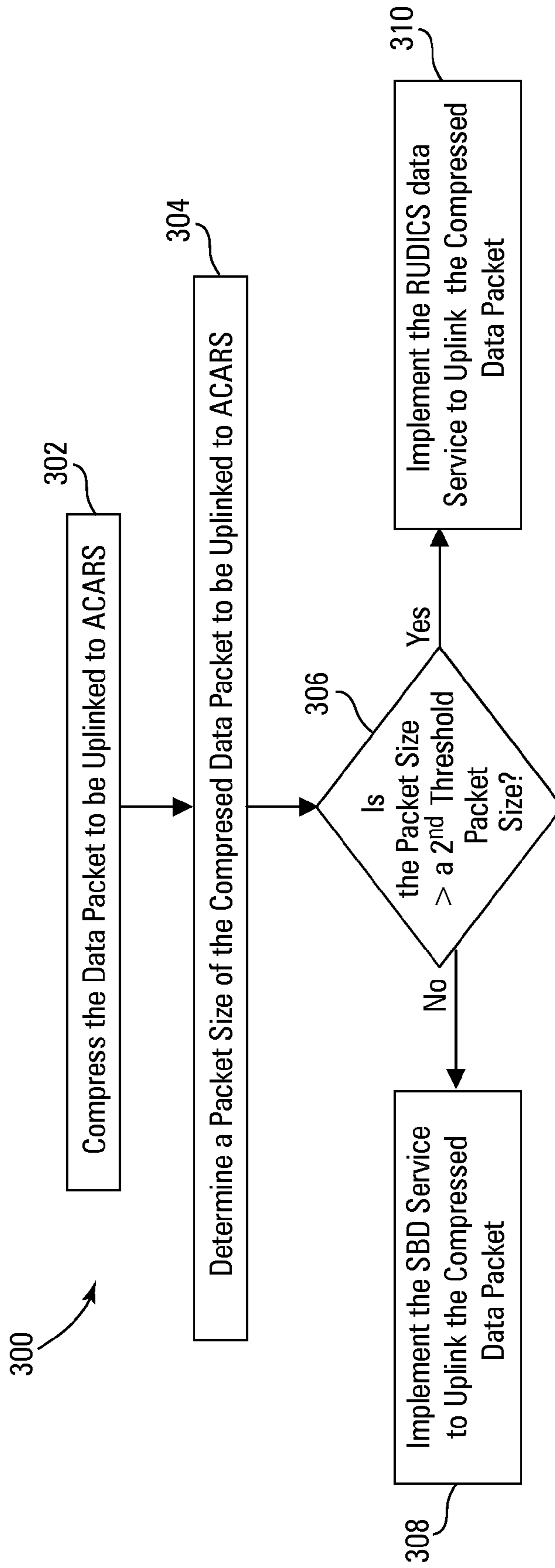


Fig. 2



*Fig. 3*



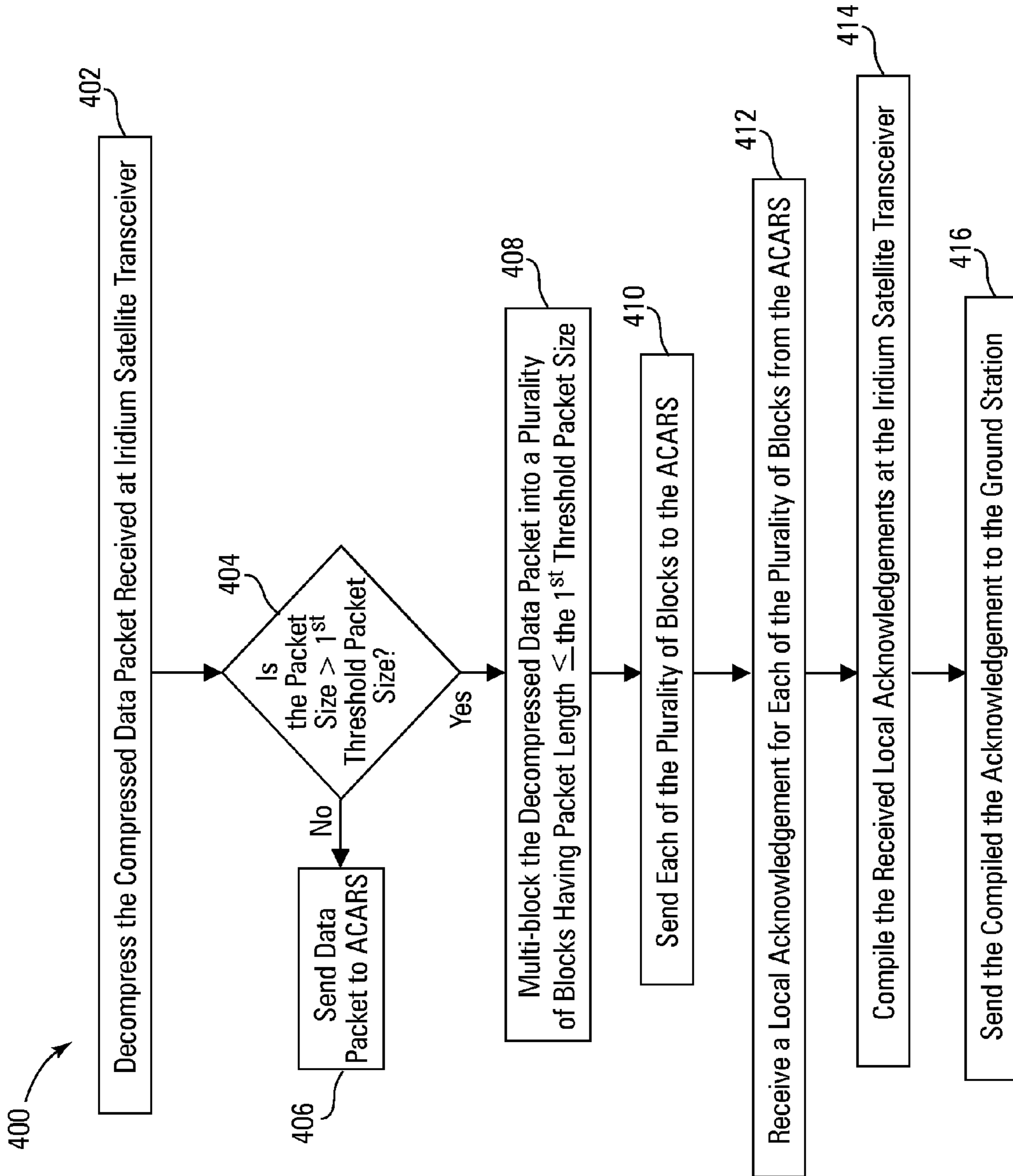


Fig. 4

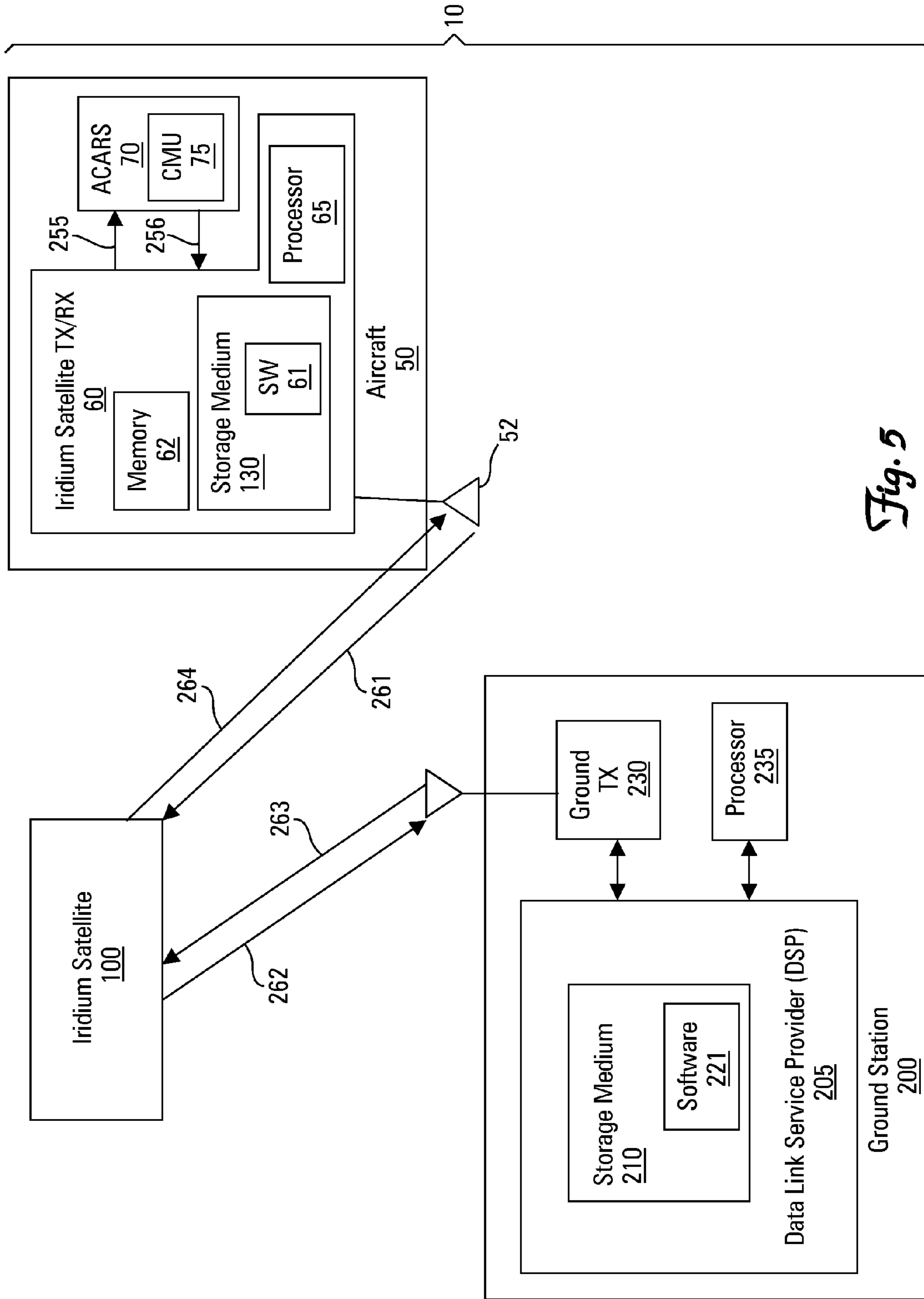


Fig. 5

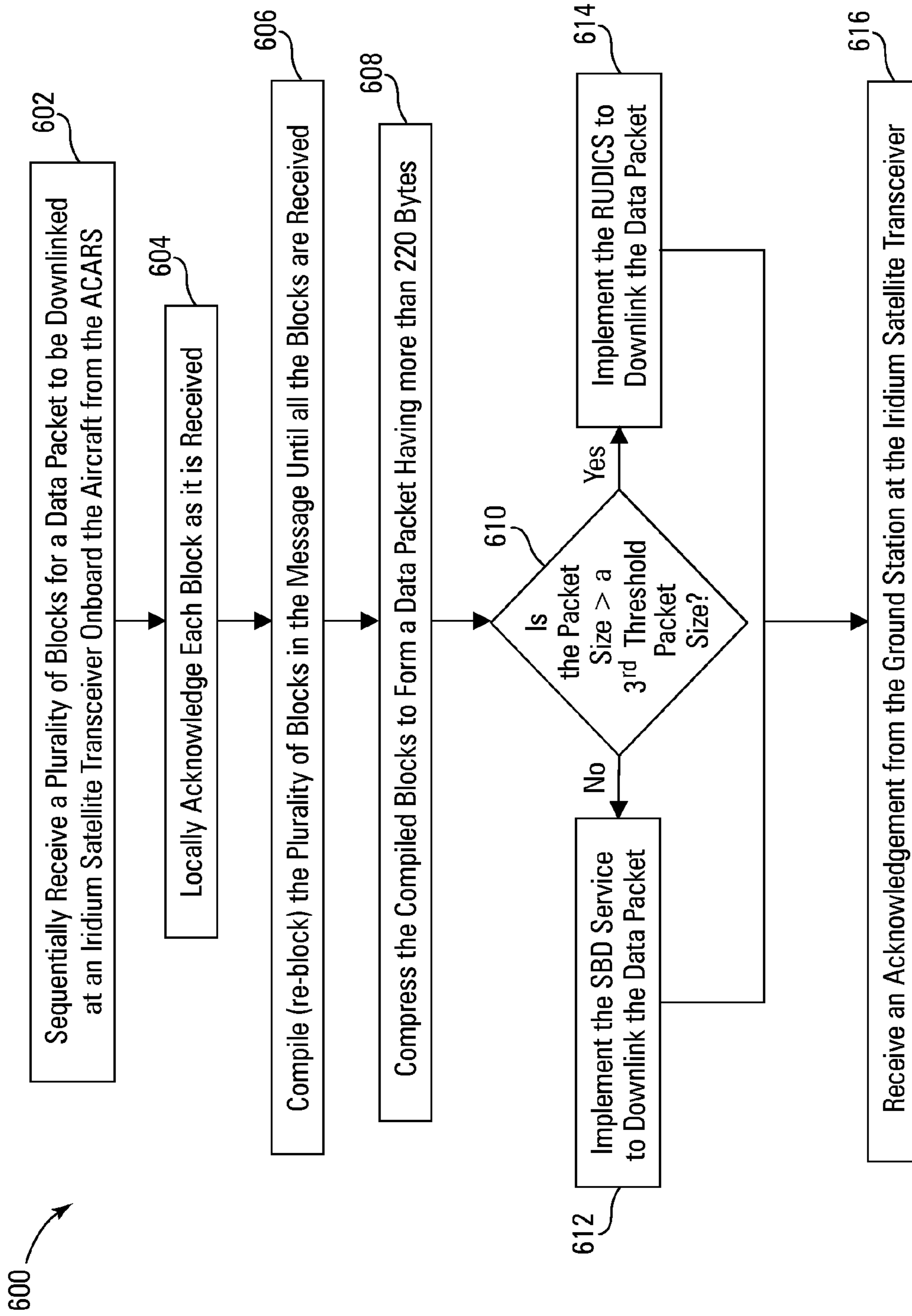


Fig. 6



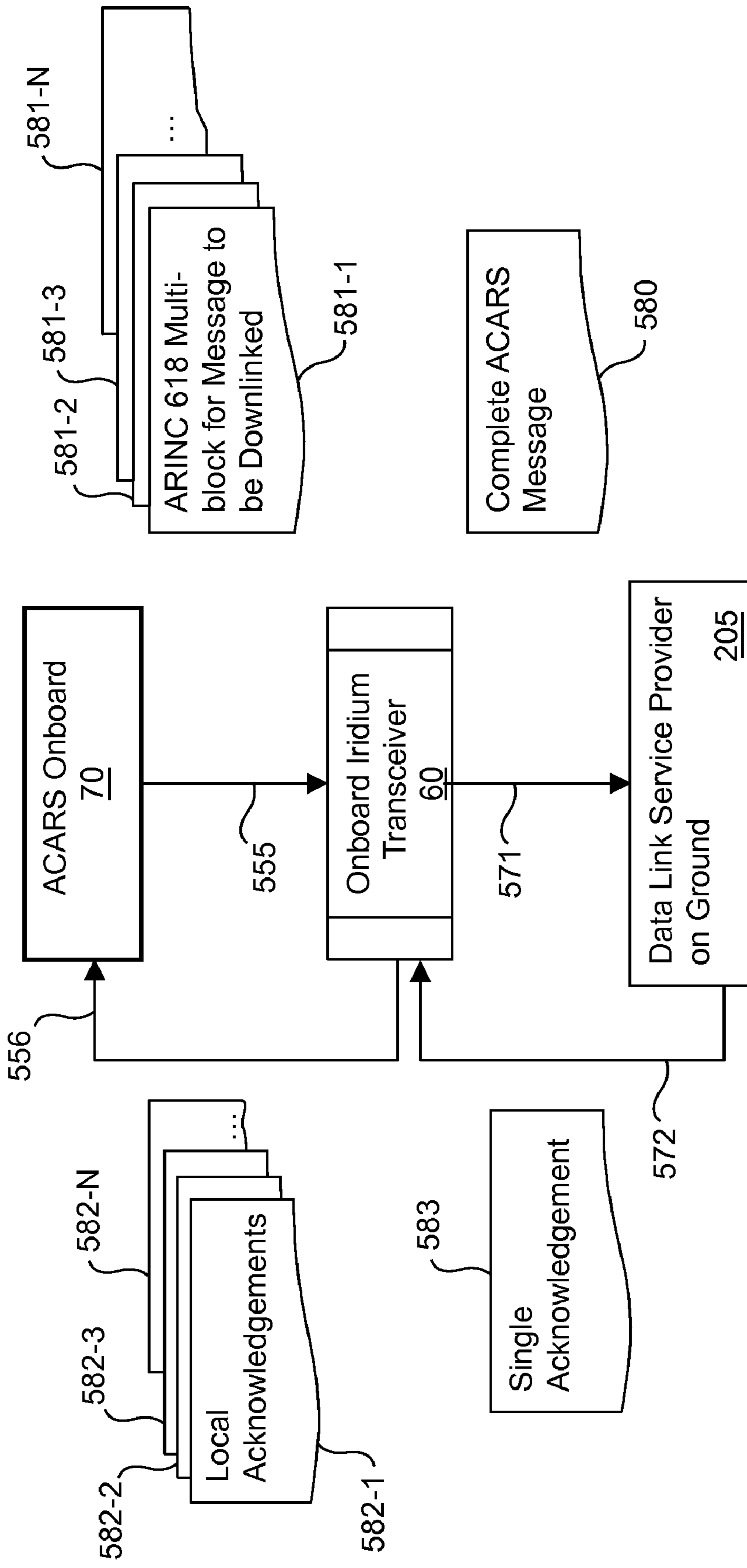


Fig. 7

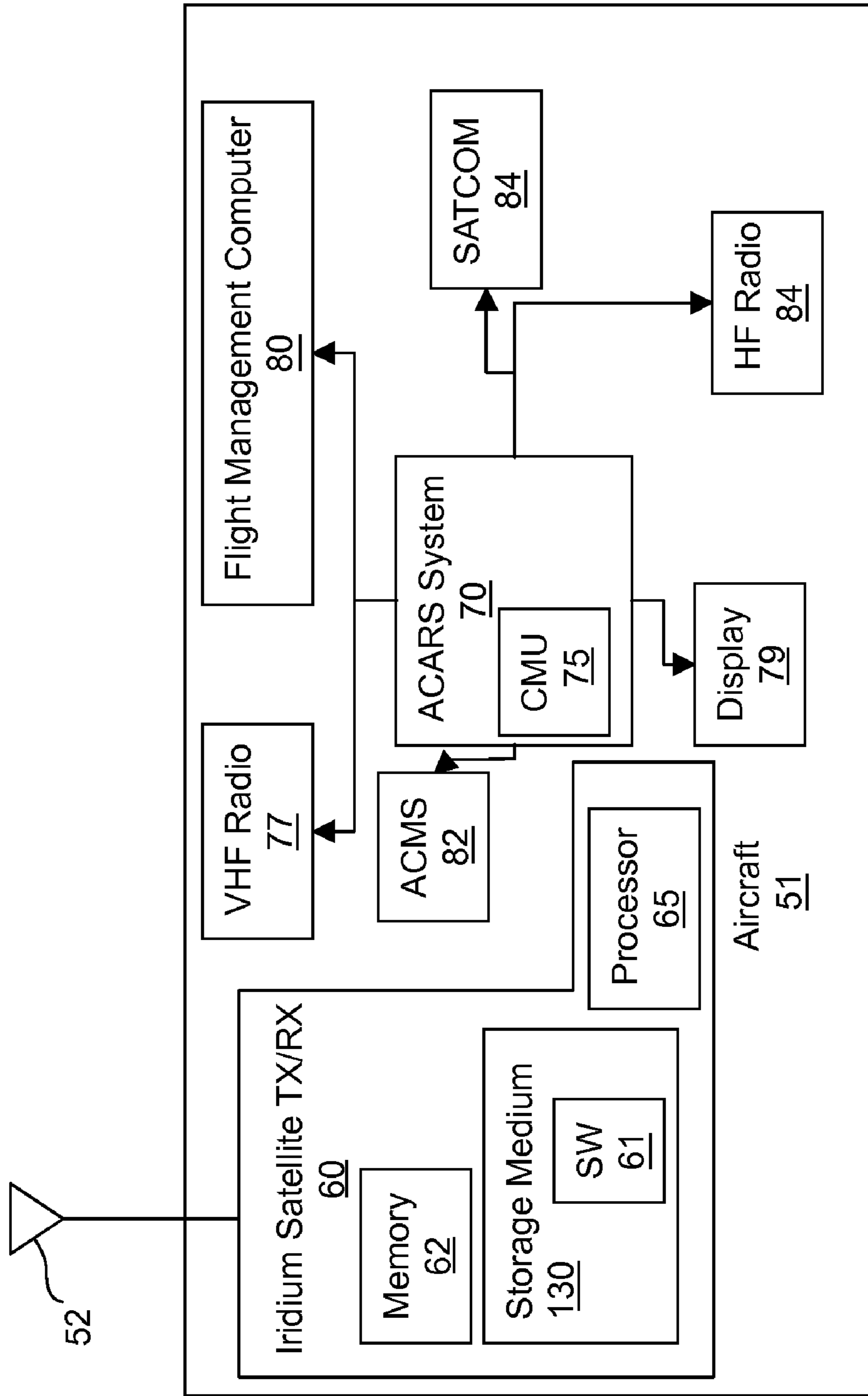


Fig. 8

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## ENHANCED DATA LINK COMMUNICATION OVER IRIDIUM

### BACKGROUND

Data link communication systems transmit messages between aircraft and ground stations via radio or satellite. A network of ground radio stations ensure that aircraft can communicate with ground in real-time from practically anywhere in the world. Satellites are used over oceans or remote areas where no ground stations exist. Aircraft communications addressing and reporting system (ACARS) is a data link system that handles text-based information of essentially the same type as can be sent via ground-ground telex. A person or a system on board creates a message and sends it via ACARS to a system or user on the ground and vice versa. Messages are sent both automatically and manually.

There are three major components to the ACARS data link system: aircraft equipment, service providers, and ground processing systems. An ACARS communications management unit (CMU or MU) is on board the aircraft. The MU is connected to a number of other devices on board the airplane: a very high frequency (VHF) radio, a keyboard and display for the pilot master control display unit (MCDU) and a printer. In some cases, the CMU is also connected to other systems.

The data link service provider delivers a message from the aircraft to the ground station, and vice versa. The data link service provider operates a network of ACARS VHF remote ground stations (RGSs). Service providers also provide service via SATCOM and HF data link as an alternative to VHF to provide full data link capability also in remote areas or over oceans.

The ground processing system, such as Honeywell's global data centre (GDC), performs all data link-specific tasks, maintains connection with service providers, logs messages, etc. The ground processing system's data link application, such as, weather information and flight planning engine, is connected to back-end computer systems at the ground processing system. The ground processing system and ACARS together provide real-time communication between the ground and aircraft.

There are technical limitations of currently available data link communications. The ACARS data link is limited by a low-speed air/ground VHF link. Messages must be kept short, since the delivery performance decreases exponentially with message size. The maximum block size of the data link message for the ACARS data link is 220 characters or less. The average real-life performance has an end-to-end delivery time of 10-20 seconds in the uplink message, and 5-10 seconds in the downlink message. In the case of multi-block uplinks, the system experiences high latency.

Current AirSat II Iridium satellite communication systems are designed to establish connection to ACARS communications management units allowing the transfer of information to and from the ground processing system, such as Honeywell Global Data Center, using the standard Airborne Flight Information System (AFIS) protocol. The AFIS protocol has a limit on message size that can be datalinked.

### SUMMARY

The present application relates to a method to reduce latency in a data link communication. The method includes compressing a data packet to be uplinked from a ground station to an aircraft communications addressing and reporting system (ACARS) in an aircraft and determining a packet

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size of the compressed data packet. The aircraft communications addressing and reporting system is configured to receive packets having a packet size less than or equal to a first threshold packet size. The method implements an Iridium router based unrestricted digital inter-working connectivity solution data service to uplink the compressed data packet if the packet size exceeds a second threshold packet size, and implements a short burst data service to uplink the compressed data packet if the packet size is less than or equal to the second threshold packet size.

### DRAWINGS

FIG. 1 shows an uplink of messages in a data link communication system in accordance with an embodiment of the present invention;

FIG. 2 shows a flow diagram for the uplink of messages and downlink of acknowledgements in the data link communication system in accordance with an embodiment of the present invention;

FIG. 3 is a flow diagram of a method to reduce latency in a data link communication system while uplinking data packets of increased packet size from a ground station to an aircraft in accordance with an embodiment of the present invention;

FIG. 4 is a flow diagram of a method to reduce latency in a data link communication system while uplinking data packets of increased packet size within an aircraft in accordance with an embodiment of the present invention;

FIG. 5 shows a downlink of messages in an embodiment of a data link communication system in accordance with the present invention;

FIG. 6 is a flow diagram of a method to reduce latency in a data link communication while downlinking data packets of increased packet size from an ACARS in an aircraft to a ground station in accordance with an embodiment of the present invention;

FIG. 7 shows a flow diagram for the downlink of messages and uplink of acknowledgements in the data link communication system in accordance with an embodiment of the present invention; and

FIG. 8 shows an aircraft having an Iridium satellite transceiver and an ACARS in accordance with an embodiment of the present invention.

In accordance with common practice, the various described features are not drawn to scale but are drawn to emphasize features relevant to the present invention. Like reference characters denote like elements throughout figures and text.

### DETAILED DESCRIPTION

In the following detailed description, reference is made to the accompanying drawings that form a part hereof, and in which is shown by way of illustration specific illustrative embodiments in which the invention may be practiced. These embodiments are described in sufficient detail to enable those skilled in the art to practice the invention, and it is to be understood that other embodiments may be utilized and that logical, mechanical and electrical changes may be made without departing from the scope of the present invention. The following detailed description is, therefore, not to be taken in a limiting sense.

Embodiments of data link communication systems described herein transmit messages (referred to herein as data packets) between aircraft and ground stations via an Iridium satellite, in which the message size is increased while the system latency is maintained or reduced. Embodiments of the



methods to reduce latency in a data link communication described herein permit a compressed (or uncompressed) data packet to be sent from a ground station to an aircraft housing the aircraft communications addressing and reporting system via an Iridium satellite, even if the compressed (or uncompressed) data packet has a packet size greater than the packet size that the aircraft communications addressing and reporting system (ACARS) can receive. The data packet is multi-blocked into packets at an Iridium satellite transceiver in the aircraft, as necessary, so the packets sent from the Iridium satellite transceiver to the ACARS are of acceptable packet size at the ACARS.

Embodiments of the methods to reduce latency in a data link communication described herein permit a compressed (or uncompressed) data packet to be sent from an aircraft housing the aircraft communications addressing and reporting system via an Iridium satellite to a ground station, even if the compressed (or uncompressed) data packet has a packet size greater than the packet size that the aircraft communications addressing and reporting system (ACARS) can send. The packets or blocks for a message to be downlinked are received from the ACARS at the Iridium satellite transceiver, formed into a data packet at the Iridium satellite transceiver, and compressed (or not in some embodiments) so the data packet sent from the Iridium satellite transceiver to the ground station has a packet size greater than the packet size that the aircraft communications addressing and reporting system (ACARS) can send.

FIG. 1 shows an uplink of messages in a data link communication system **10** in accordance with an embodiment of the present invention. The data link communication system **10** is an ACARS based system. Thus, the data link communication system **10** is operable to increase the bandwidth and data service of the ACARS **70** on board an aircraft **50** by compressing the data being data-linked, by increasing the data link message block size, and by intelligently selecting either a short burst data (SBD) service or an Iridium router based unrestricted digital inter-working connectivity solution (RUDICS) data service. The intelligent selection of SBD service or an RUDICS data service is based on the size of the message, type of message, and type of uplink/downlink (that is, multi-block or single block).

The data link communication system **10** includes a ground station **200**, an Iridium satellite **100**, and an Iridium satellite transceiver **60** and ACARS **70** positioned in an aircraft **50**. The Iridium satellite transceiver **60** includes software **61** located in a storage medium **130**. The ground station **200** houses a data link service provider (DSP) **205** including software **221** located in storage medium **210**. The software **221** in the data link service provider **205** in the ground station **200** and the software **61** in the Iridium satellite transceiver **60** modify all messages to be uplinked (uplinked messages) transmitted from the ground station **200** to the aircraft **50** that are longer than a first threshold packet size. In one implementation of this embodiment, the first threshold packet size is 220 bytes. In another implementation of this embodiment, the first threshold packet size is other than 220 bytes. The software **61** in the Iridium satellite transceiver **60** modifies all messages to be downlinked (downlink messages) transmitted from the aircraft **50** to the ground station **200** that are longer than a first threshold packet size. This message modification advantageously implements the capability of the Iridium satellite **100** in order to reduce the latency of the data link communication system **10**. The modifications of the uplinked and downlinked messages are based on the size of the message, the type of message, and the type of uplink/downlink (i.e., multi-block or single block) as described herein.

The Iridium satellite transceiver **60** and the Iridium satellite **100** are enabled for SBD service and for RUDICS data service. The Iridium satellite transceiver **60** is communicatively coupled to the co-located ACARS **70**, which includes an ACARS communications management unit (CMU) **75**. In one implementation of this embodiment, the ACARS **70** includes an ACARS management unit (MU). The Iridium satellite transceiver **60** is communicatively coupled to the aircraft antenna **52**. The aircraft antenna **52** is communicatively coupled to the Iridium satellite **100** via communication links **252** and **253** (uplink and down link, respectively). The Iridium satellite **100** is communicatively coupled to the ground station **200** via communication links **251** and **254** (uplink and down link, respectively). In this manner, the Iridium satellite transceiver **60** is communicatively coupled to the ground station **200**.

The communication links **252** and **253** are shown as separate communication links for ease of viewing but in some embodiments they are the same wireless communication link. Likewise, the communication links **251** and **254** are shown as separate communication links but in some embodiments they are the same wireless communication link.

SBD is an efficient, packet-based service for frequent short data transmissions that typically are less than 500 bytes per transfer. The SBD service supports 1960 bytes Mobile Originated data packet (i.e., downlink data packet) and 1890 bytes Mobile Terminated data packet (i.e., uplink data packet). In SBD-based data transfer, the packet switching opens the connection just long enough to send a data packet and then closes. RUDICS is a circuit switched data service designed for transfer of data packets that typically are 500 bytes or more per transfer. In RUDICS-based data transfer, the packet switching opens a connection and keeps it open until the last bit of data for the session is sent. The circuit is pre-defined before the connection is made.

The processors **65** and **235** execute software **61** and **221**, respectively, and/or firmware that causes the processors **65** and **235** to perform at least some of the processing described here as being performed by the Iridium satellite transceiver **60** and data link service provider **205**, respectively. The software **61** and **221** and/or firmware executed by the processors **65** and **235**, respectively, comprise a plurality of program instructions that are stored or otherwise embodied on a storage media **130** and **210**, respectively, from which at least a portion of such program instructions are read for execution by the processors **65** and **235**, respectively. In one implementation, the processors **65** and **235** comprise a microprocessor or microcontroller. In another implementation, the processors **65** and **235** comprise processor support chips and/or system support chips such as application-specific integrated circuits (ASICs).

As described above, the ACARS **70** is programmed to accept only messages with a packet size of 220 bytes or less while the Iridium satellite transceiver **60** is able to receive messages with a packet size greater than 220 bytes. The Iridium satellite transceiver **60** multi-blocks the messages with packet size greater than 220 bytes to increase the latency of the data link system **10**. As defined herein a "length in bytes of a data packet" is the "packet size."

FIG. 2 shows a flow diagram for the uplink of messages and downlink of acknowledgements in the data link communication system **10** in accordance with an embodiment of the present invention. A data packet **280** (complete ACARS message) is generated at the data link service provider **205** (FIG. 1) and transmitted via communication link **271** to the Iridium satellite. In one implementation of this embodiment, the processor **235** executes software **221** stored in the storage



medium **210** of the data link service provider **205** to compress the data packet **280**. The methods described herein include the steps of compression/decompression but one skilled in the art can understand how to implement the methods described herein without the steps of compression/decompression after reading this document.

An exemplary case for a data packet **280** is compressed to X bytes in length (X is an integer) is now described. If X is less than or equal to a second threshold packet size, such as 1890 bytes (i.e., compressed data packet **280** is less than or equal to 1890 bytes in length), the processor **235** then executes software **221** to configure the data packet **280** for SBD transmission. If X is greater than the second threshold packet size 1890 (i.e., compressed data packet **280** is greater than 1890 bytes in length), the processor **235** then executes software **221** to configure the compressed data as an uplinked data packet **280** for RUDICS transmission. In one implementation of this embodiment, 1890 bytes is a second threshold packet size. In another implementation of this embodiment, the second threshold packet size is different from 1890 bytes.

The compressed data packet **280** transmitted from the ground antenna **202** is received at the Iridium satellite **100** over communication link **251**. The Iridium satellite **100** sends the received data packet via communication link **252** to the aircraft **50**. The communication links **251** and **252** in FIG. 1 are represented generally as a single communication link **271** in FIG. 2. The compressed data packets **280** received at the Iridium satellite transceiver **60** are decompressed by the Iridium satellite transceiver **60**. If the decompressed data packet exceeds the first threshold packet size, such as 220 bytes, the data packet is segmented into a plurality of blocks **281(1-N)** (ARINC 618 multi-block for message to be uplinked). The blocks **281(1-N)** are also referred to herein as “packets 281 (1-N).” Each of the plurality of blocks **281(1-N)** has a packet size less than or equal to 220 bytes in length. Specifically, the processor **65** executes the software **61** in the Iridium satellite transceiver **60** to decompress the data in the data packet **280** and to multi-block any decompressed data packet **280** that exceed 220 bytes into 220 byte blocks **281(1-N)**. In this manner, the data packet **280** is reformed as blocks **281(1-N)** and the blocks **281(1-N)** are sent to the ACARS **70** while the data link communication system **10** has reduced the system redundancy.

The number N of blocks **281(1-N)** of 220 bytes is  $(X/220)$ , where the  $(X/220)$  is rounded up to the next higher integer when  $(X/220)$  is not an integer. Thus, when the number  $(X/220)$  is an integer, all the packets have a packet length of 220 bytes. When the number  $(X/220)$  is not an integer,  $X/220$  is rounded up to the next higher integer and the last block **281-N** has a packet length of less than 220 bytes. The multi-blocked messages are sent to the ACARS **70** via communication link **255**. The blocks **281(1-N)** sent over communication link **255** are of packet sizes that are acceptable by the ACARS **70** for processing by the communication management unit **75**. Since the data packet **280** is transmitted from the ground station to the aircraft **50** with a packet size greater than the first the threshold packet size (for example, 220 bytes), the system latency for the data link communication system **10** is reduced.

For each block **281(1-N)** received at the ACARS **70**, a respective local acknowledgement **282(1-N)** is sent via communication link **256** to the onboard Iridium satellite transceiver **60**. The local acknowledgments **282(1-N)** are stored in the Iridium satellite transceiver **60** until acknowledgements **282(1-N)** are received for all the blocks **281(1-N)**. Once all the acknowledgements **282(1-N)** are received, the Iridium satellite transceiver **60** re-blocks the plurality of local

acknowledgements **282(1-N)** to generate a single acknowledgement **283**. The single acknowledgement **283** is sent to the Iridium satellite **100** via communication link **253** and from the Iridium satellite **100** to the ground station **200** via communication link **254**. The communication links **253** and **254** in FIG. 1 are shown as **272** in FIG. 2. In one implementation of this embodiment, the local acknowledgements **282(1-N)** are stored in memory **62** in the Iridium satellite transceiver **60**. In another implementation of this embodiment, the memory is part of the processor **65**. In yet another implementation of this embodiment, the re-blocked single acknowledgement is compressed to form a compressed acknowledgement. The Iridium satellite transceiver is configured to implement the Iridium router based unrestricted digital inter-working connectivity solution data service to downlink the acknowledgement, if the packet size of the single acknowledgement is greater than a third threshold packet size, such as 1960 bytes.

In one implementation of this embodiment, the data packet **280** formed after compression is less than 1890 bytes in length, so the data link service provider **205** implements the SBD service to uplink data packet **280** to the Iridium satellite transceiver **60**. In another implementation of this embodiment the data packet **280** formed after compression is greater than or equal to 1890 bytes in length, so the data link service provider **205** implements the RUDICS data service to uplink data packet **280** of to the Iridium satellite transceiver **60**.

FIG. 3 is a flow diagram of a method **300** to reduce latency in a data link communication system **10** while uplinking data packets of increased packet size from a ground station **200** to an aircraft **50** in accordance with an embodiment of the present invention. In one implementation of this embodiment, the data link communication system **10** is the ACARS based system described above with reference to FIGS. 1-2. The method **300** is described with reference to the link communication system **10** shown in FIG. 1 although it is to be understood that method **300** can be implemented using other embodiments of the data link communication system as is understandable by one skilled in the art who reads this document.

At block **302**, the data in the data packet to be uplinked from a ground station **200** to an aircraft communications addressing and reporting system (ACARS) **70** in an aircraft **50** is compressed. The ACARS **70** is configured to receive packets (also referred to herein as “blocks”) having a packet size less than or equal to a first threshold packet size. In one implementation of this embodiment, the first threshold packet size is 220 bytes. The data packet **280** shown in FIG. 2 is an exemplary compressed data packet. At block **304**, the data link service provider **205** determines the packet size of the compressed data packet, such as data packet **280**. At block **306**, it is determined if a packet size of the compressed data packet **280** to be uplinked from a ground station **200** to an aircraft communications addressing and reporting system (ACARS) **70** in an aircraft **50** exceeds a second threshold packet size. Specifically, the data link service provider **205** determines if the packet size of the compressed data packet **280** is greater than the second threshold packet size. If the packet size is less than or equal to the second threshold packet size, the flow proceeds to block **308** and a short burst data service is implemented to send the compressed data packet to the aircraft **50**. If the packet size is greater than the second threshold packet size, the flow proceeds to block **310**. At block **310**, the Iridium router based unrestricted digital inter-working connectivity solution data service is implemented to send the compressed data packet **280** to the aircraft **50**.

FIG. 4 is a flow diagram of a method **400** to reduce latency in a data link communication system **10** while uplinking data



packets of increased packet size within an aircraft **50** in accordance with an embodiment of the present invention. In one implementation of this embodiment, the data link communication system **10** is the ACARS based system described above with reference to FIGS. **1-2**. The method **400** is described with reference to the link communication system **10** shown in FIG. **1** although it is to be understood that method **400** can be implemented using other embodiments of the data link communication system as is understandable by one skilled in the art who reads this document. The method **400** is implemented after the process of block **308** or **310** is implemented, as described above with reference to FIG. **3**, and a data packet is sent to the Iridium satellite transceiver **60** via communication link **251**, the Iridium satellite **100**, and communication link **253**.

At block **402**, the compressed data packet received at Iridium satellite transceiver **60** in the aircraft **50** from a ground station **200** is decompressed. In one implementation of this embodiment, the packet size of the compressed data packet is greater than a first threshold packet size. At block **404**, it is determined if the packet size is greater than the first threshold packet size. In one implementation of this embodiment, it is determined if the packet size is greater than 220 bytes. If the packet size is less than or equal to the first threshold packet size, the flow proceeds block **406** and the data packet is sent to ACARS **70**. If the packet size is greater than the first threshold packet size, the flow proceeds block **408**. At block **408**, the decompressed data packet is multi-blocked into a plurality of blocks, so the number of bytes in each block is less than or equal to the first threshold packet size (such as 220 bytes). At block **410**, each of the plurality of blocks or packets is sent to the ACARS **70** onboard the aircraft **50**.

At block **412**, a local acknowledgement **282-i** for each  $i^{th}$  uplinked block is sequentially received at the Iridium satellite transceiver **60** from the aircraft communications addressing and reporting system **70** onboard the aircraft **50**. The Iridium satellite transceiver **60** receives all of the local acknowledgements **282(1-N)**. At block **414**, the Iridium satellite transceiver **60** compiles all of the received local acknowledgements **282(1-N)**. When the local acknowledgements **282(1-N)** for each of the plurality of blocks **281(1-N)** are compiled, block **416** is implemented. At block **416**, the Iridium satellite transceiver **60** sends the compiled acknowledgement as a single acknowledgement **283** to the ground station **200**. In one implementation of this embodiment, the Iridium satellite transceiver **60** compresses the compiled acknowledgement **283**. In another implementation of this embodiment, the number of bytes in the single acknowledgement **283** is greater than the first threshold packet size.

FIG. **5** shows a downlink of messages in an embodiment of a data link communication system **10** in accordance with the present invention. FIG. **5** differs from FIG. **1** in that data packets are downlinked via communication link **264** from the Iridium satellite transceiver **60** in the aircraft **50** to the Iridium satellite **100** and via communication link **262** from the Iridium satellite **100** to the ground station transceiver **230** in the ground station **200**. Likewise, an acknowledgement is sent from the ground station **200** via communication link **263** to the Iridium satellite **100** and via communication link **264** from the Iridium satellite **100** to the Iridium satellite transceiver **60** in the aircraft **50**. The communication links **262** and **263**, which are shown as separate communication links, are a single bidirectional wireless communication link. Likewise, the communication links **254** and **251** in FIG. **1** are the same bidirectional wireless communication links as communication links **262** and **263**. The communication links **261** and **264**, which are shown as separate communication links, are a

bidirectional single wireless communication link. Likewise, the communication links **252** and **253** in FIG. **1** are the same bidirectional single wireless communication links as communication links **261** and **264**.

FIG. **6** is a flow diagram of a method **600** to reduce latency in a data link communication system **10** while downlinking data packets of increased packet size from an ACARS **70** in an aircraft **50** to a ground station **200** in accordance with an embodiment of the present invention. FIG. **7** shows a flow diagram for the downlink of messages **580** and uplink of acknowledgements **583** in the data link communication system **10** in accordance with an embodiment of the present invention. The method **600** is described with reference to FIG. **7** and the link communication system **10** shown in FIG. **5** although it is to be understood that method **600** can be implemented using other embodiments of the data link communication system as is understandable by one skilled in the art who reads this document.

At block **602**, a plurality of blocks **581(1-N)** (ARINC 618 multi-block for message to be downlinked) for a message to be downlinked are sequentially received at the Iridium satellite transceiver **60** onboard the aircraft **50** from the ACARS **70**. The blocks **581(1-N)** are also referred to herein as “packets **581(1-N)**.” The plurality of blocks **581(1-N)** are each less than or equal to 220 bytes in length. The plurality of blocks **581(1-N)** is sent via communication link **555** (FIG. **7**) to the Iridium satellite transceiver **60**. At block **604**, the Iridium satellite transceiver **60** sends a local acknowledgement to the ACARS **70** for each block **581(1-N)** as it is received. The local acknowledgements **582(1-N)** are sent from the Iridium satellite transceiver **60** to the ACARS **70** via communication link **556** (FIG. **7**).

At block **606**, the plurality of blocks **581(1-N)** in the message that are sequentially received from the ACARS **70** are compiled (also referred to herein as “re-blocked”) at the Iridium satellite transceiver **60** until all the blocks **581(1-N)** are received for the message to be downlinked. Each block **581(1-N)** has a packet size less than or equal to 220 bytes and the re-blocked plurality of blocks form a data packet to be downlinked that has more than the first threshold packet size. In one implementation of this embodiment, the plurality of blocks **581(1-N)** is stored in the memory **62** until all the blocks **581(1-N)** are received and then the processor **65** compiles the plurality of blocks **581(1-N)**.

At block **608**, the compiled blocks are compressed to form a data packet **580** to be downlinked. In one implementation of this embodiment, the compressed data packet **580** to be downlinked has a packet size greater than the first threshold packet size. In another implementation of this embodiment, block **608** is not implemented. The Iridium satellite transceiver **60** determines the packet size of the compressed data packet **580** to be downlinked. At block **610**, the Iridium satellite transceiver **60** determines if the packet size of the compressed data packet **580** is greater than a third threshold packet size. In one implementation of this embodiment, the third threshold packet size is 1960 bytes. In another implementation of this embodiment, the third threshold packet size is different from 1960 bytes.

If the packet size of the compressed data packet **580** is less than or equal to the third threshold packet size, the flow proceeds to block **612**. At block **612**, the Iridium satellite transceiver **60** implements the short burst data service to downlink the compressed data packet **580** via an Iridium satellite **100**. The downlinked data packet **580** can have a packet size greater than the first threshold packet size.

If the packet size of the compressed data packet **580** is greater than the third threshold packet size, the flow proceeds



to block 614. At block 614, the Iridium satellite transceiver 60 implements the RUDICS data service to downlink the compressed data packet. In this case, the downlinked compressed data packet 580 has a packet size greater than the third threshold packet size.

At block 616, the Iridium satellite transceiver 60 receives an acknowledgement 583 from the ground station 200 after the ground station 200 receives the downlinked data packet 580. The Iridium satellite transceiver 60 segments the single acknowledgement 583 into a plurality of blocks 582(1-N). Each block 582-*i* is sequentially sent from the Iridium satellite transceiver 60 to the ACARS 70. Each of the blocks 582(1-N) is less than the first threshold packet size.

FIG. 8 shows an aircraft 51 having an Iridium satellite transceiver 60 and an ACARS 70 in accordance with an embodiment of the present invention. The aircraft 51 includes the Iridium satellite transceiver 60 communicatively coupled to an antenna 52 and the ACARS 70 as described above with reference to FIG. 1. As shown in FIG. 8, the communication management unit 75 in the ACARS 70 is communicatively coupled to a very high frequency (VHF) radio 77, a display 79 for the pilot, a flight management computer 80, aircraft condition monitoring system (ACMS) 82, satellite communications (SATCOM) 84, and a high frequency (HF) radio 84. In one implementation of this embodiment, a printer and a keyboard are communicatively coupled to the communication management unit 75. The aircraft 51 can be used to implement the methods 300, 400 and 600 in a system with the Iridium satellite 100 and a ground station 200 as is understandable by one skilled in the art reading this document.

Although specific embodiments have been illustrated and described herein, it will be appreciated by those of ordinary skill in the art that any arrangement, which is calculated to achieve the same purpose, may be substituted for the specific embodiment shown. This application is intended to cover any adaptations or variations of the present invention. Therefore, it is manifestly intended that this invention be limited only by the claims and the equivalents thereof.

What is claimed is:

1. A method to reduce latency in a data link communication, the method comprising:

compressing a data packet to be uplinked from a ground station to an aircraft-communications-addressing-and-reporting-system (ACARS) device in an aircraft, the aircraft-communications-addressing-and-reporting-system device configured to receive packets having a packet size less than or equal to a first threshold packet size;

determining a packet size of the compressed data packet; when the packet size exceeds a second threshold packet size, transmitting the compressed data packet over an uplink via an Iridium-router-based-unrestricted-digital-inter-working-connectivity-solution-data service; and when the packet size is less than or equal to the second threshold packet size, transmitting the compressed data packet over the uplink via a short-burst-data service.

2. The method of claim 1, further comprising:

receiving the uplinked compressed data packet having a packet size greater than the first threshold packet size at an Iridium satellite transceiver in the aircraft;

decompressing the received data packet;

multi-blocking the decompressed data packet into a plurality of blocks, wherein the packet size of each block is less than or equal to the first threshold packet size; and sending the plurality of blocks to the aircraft-communications-addressing-and-reporting-system device onboard the aircraft.

3. The method of claim 2, further comprising:

sequentially receiving a local acknowledgement for each of the plurality of blocks at the Iridium satellite transceiver from the aircraft-communications-addressing-and-reporting-system device;

compiling the received local acknowledgements at the Iridium satellite transceiver; and

sending the compiled acknowledgements as a single acknowledgement to the ground station when the local acknowledgements for each of the plurality of blocks are compiled.

4. The method of claim 1, further comprising:

sequentially receiving a plurality of blocks for a data packet to be downlinked at an Iridium satellite transceiver onboard the aircraft from the aircraft-communications-addressing-and-reporting-system device; and locally acknowledging each block as it is received.

5. The method of claim 4, further comprising:

compiling the plurality of blocks in the data packet until all the blocks are received;

compressing the compiled blocks to form a data packet to be downlinked;

determining a packet size of the compressed data packet to be downlinked;

when the packet size of the data packet to be sent over a downlink is greater than a third threshold packet size, transmitting the compressed data packet over the downlink via the Iridium-router-based-unrestricted-digital-inter-working-connectivity-solution-data service; and

when the packet size of the data packet to be sent over the downlink is less than or equal to the third threshold packet size, transmitting the compressed data packet over the downlink via the short-burst-data service.

6. A system to enhance data link communication, the system comprising:

an aircraft-communications-addressing-and-reporting-system (ACARS) device onboard an aircraft, the aircraft-communications-addressing-and-reporting-system device configured to receive packets having a packet size less than or equal to a first threshold packet size;

an Iridium satellite transceiver onboard the aircraft, the Iridium satellite transceiver communicatively coupled to the aircraft-communications-addressing-and-reporting-system device and configured to transmit via one of an Iridium-router-based-unrestricted-digital-inter-working-connectivity-solution-data service (RUDICS) or a short-burst-data (SBD) service, the transmission being based on a packet size of a received data packet, the Iridium satellite transceiver including a processor to execute software to:

decompress an uplinked data packet; and

if the decompressed uplinked data packet has a packet size greater than the first threshold packet size, multi-block the decompressed uplinked data packet into a plurality of blocks, each block having less than the first threshold packet size, wherein the Iridium satellite transceiver sequentially sends the plurality of blocks to the aircraft-communications-addressing-and-reporting-system device.

7. The system of claim 6, further comprising at least one ground station communicatively coupled to the Iridium satellite transceiver via an Iridium satellite.

8. The system of claim 7, wherein the ground station comprises:

a data link service provider;

a ground station transceiver communicatively coupled to the data link service provider; and



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a processor communicatively coupled to the data link service provider.

9. The system of claim 8, wherein the data link service provider comprises a storage medium holding software executable by the processor to compress data packets to be uplinked and decompress data packets to be downlinked, and, when a packet size of a compressed data packet is less than or equal to a second threshold packet size, the processor is configured to transmit the compressed data packet via an uplink via short-burst-data service, and, when the packet size of the compressed data packet is greater than the second threshold size, the processor is configured to transmit the compressed data packet over the uplink via Iridium-router-based-unrestricted-digital-inter-working-connectivity-solution-data service.

10. The system of claim 6, wherein the Iridium satellite transceiver is configured to receive local acknowledgements for each of the plurality of blocks from the aircraft-communications-addressing-and-reporting-system device.

11. The system of claim 10, wherein the processor compiles the acknowledgements by executing software to re-block the local acknowledgements received from the aircraft-communications-addressing-and-reporting-system device to form a single acknowledgement.

12. The system of claim 11, wherein the Iridium satellite transceiver is configured so that, when the packet size of the single acknowledgement is greater than a third threshold packet size, the Iridium satellite transceiver transmits the acknowledgement over the downlink via the Iridium-router-based-unrestricted-digital-inter-working-connectivity-solution-data service to downlink the acknowledgement.

13. The system of claim 12, wherein the Iridium satellite transceiver is configured so that when the packet size of the data packet is less than or equal to the third threshold packet size, the Iridium satellite transceiver transmits the data packet over the downlink via the short-burst-data service.

14. The system of claim 6, the Iridium satellite transceiver comprising:

a storage medium holding software executable by the processor; and

a memory to store thresholds.

15. A method to reduce latency in a data link communication, the method comprising:

determining a packet size of a data packet to be uplinked from a ground station to an aircraft-communications-addressing-and-reporting-system (ACARS) device in an aircraft, the aircraft-communications-addressing-and-reporting-system device configured to receive packets having packet size less than or equal to a first threshold packet size;

when the packet size is less than or equal to a second threshold packet size, transmitting the data packet over an uplink via a short-burst-data service; and

when the packet size is greater than the second threshold packet size, transmitting the data packet over the uplink

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via an Iridium-router-based-unrestricted-digital-inter-working-connectivity-solution-data service.

16. The method of claim 15, further comprising: receiving the uplinked data packet having a packet size greater than the first threshold packet size at an Iridium satellite transceiver in the aircraft; multi-blocking the uplinked data packet into a plurality of blocks, wherein the packet size of each block is less than or equal to the first threshold packet size; and sending the plurality of blocks to the aircraft-communications-addressing-and-reporting-system device onboard the aircraft.

17. The method of claim 16, further comprising: sending a local acknowledgement for each uplinked block from the aircraft-communications-addressing-and-reporting-system device onboard the aircraft to the Iridium satellite transceiver; compiling the received local acknowledgements at the Iridium satellite transceiver; and sending the compiled acknowledgements as a single acknowledgement to the ground station when an acknowledgement is received at the Iridium satellite transceiver for each of the plurality of blocks.

18. The method of claim 15, further comprising: sequentially receiving a plurality of blocks for a data packet to be downlinked at an Iridium satellite transceiver onboard the aircraft from the aircraft-communications-addressing-and-reporting-system device; and locally acknowledging each block as it is received from the aircraft-communications-addressing-and-reporting-system device.

19. The method of claim 18, further comprising: compiling the plurality of blocks for the data packet to be downlinked;

determining the packet size of the data packet to be downlinked;

when the packet size of the data packet to be sent over a downlink is greater than a third threshold packet size, transmitting the data packet over the downlink via the Iridium-router-based-unrestricted-digital-inter-working-connectivity-solution-data service; and

when the packet size of the data packet to be sent over the downlink is less than or equal to the third threshold packet size, transmitting the data packet over the downlink via the short-burst-data service.

20. The method of claim 15, further comprising: compressing the data packet to be uplinked from the ground station to the Iridium satellite transceiver; decompressing the uplinked compressed data packet received at the Iridium satellite transceiver; compressing a data packet to be downlinked from the Iridium satellite transceiver to the ground station; and decompressing the downlinked compressed data packet received at the ground station.

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